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SOYBEANS:

ACREAGE RESPONSE TO PRICE AND FARM PROGRAM CHANGES

ECONOMIC RESEARCH SERVICE

U.S. DEPARTMENT OF AGRICULTURE

ABSTRACT

Linear programming and regression analyses are used to estimate U.S. planted acreage of soybeans with expected prices of $2.50, $2.20, $2, and $1.80 per bushel. The linear programming analysis assumes programs of the Agricultural Act of 1965 are in effect. Changes in soybean acreage induced by reductions in the loan rate for feed grain and changes in the domestic allotment for cotton are also estimated. An expected price of $2.50 for soybeans induced an estimated 1.2-million-acre increase over the prior year with 1969 specifications of the Agricultural Act of 1965 in effect. The estimated change in planted acres successively declined about 1 million acres as the price expectations were successively dropped from $2.50 to $2.20, then to $2 and to $1.80.

The regression analysis is based on the period 1946-69. Independent variables include acreage in previous year, restrictions in effect for feed grains, and returns above fertilizer costs for soybeans and major competing crops. When the absolute acreage of soybeans was used as the independent variable, estimates from regression analysis were similar to those from linear programming. When the first difference in soybean acreage is used as the dependent variable, the estimates differ only in that the increase in acreage over the previous year is higher than the other estimates for each price level.

Keywords: *Soybeans, production response, government programs, supply response, linear programming, regression analysis.*

PREFACE

This report of soybean supply response is derived from a continuing study of aggregate production response and resource adjustments to changes in prices, costs, factor supplies, and Government programs by the Aggregate Production Analysis Team of the Farm Production Economics Division, Economic Research Service, USDA. This team is the Production Response Group of the Production Adjustments Branch, FPED, and six FPED regional analysts in field offices across the United States.

The team used an integrated research system which brings together available data, econometric techniques, and individual expert judgment. This research system is known as the Aggregate Production Analysis System, which has been described by Schaller and Sharples (Schaller, W. Neill, "A National Model of Agricultural Production Response," Agr. Econ. Res. 20:33-46, Apr. 1968; Sharples, Jerry A. and W. Neill Schaller, "Predicting Short-Run Aggregate Adjustment to Policy Alternatives," Amer. Jour. Agr. Econ. 50:1523-1536, Dec. 1968).

The Aggregate Production Analysis System combines linear programming (at both farm and area levels), multiple regression, and other statistical techniques. It provides a means for combining the judgment of economists of the Aggregate Production Analysis Team, the Farm Production Economics Division, and several land-grant universities.

W.C. McArthur, T.A. Miller, P.L. Strickland, and G.W. Worden, FPED, contributed linear programming analyses for the Southeast, Great Plains, Delta, and North Central regions, respectively.

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HIGHLIGHTS

A programming model estimated a reduction of 600,000 acres, or 1.4 percent, in land planted to soybeans as the price received for soybeans was reduced from $2.50 to $2.20 per bushel. A further reduction in price, from $2.20 to $2 per bushel, would reduce planted acreage by another 1.7 million acres, or 4.1 percent of the acreage at $2.20 per bushel. A still further reduction in price—from $2 to $1.80—would reduce acreage by 1.4 million acres, or 3.5 percent of the acreage at $2 per bushel.

Regression analysis indicates that harvested acreage of soybeans is reduced approximately 1 million acres as the soybean price for the previous year is successively reduced from $2.50 a bushel to $2.20, from $2.20 to $2, and from $2 to $1.80.

Regression analysis, using absolute acreage of soybeans as the independent variable, also indicates that with soybeans selling at $2.50 per bushel, the acreage in the following year will increase approximately 1.2 million acres. If the change in soybean acreage is used as the independent variable, the estimated increase in acreage over the previous year is approximately 1.9 million acres.

Controls on acreages of feed grains, wheat, and cotton have contributed to the long-term increase in soybean acreage. When controls on corn were removed in 1959, soybean acreage declined 7 percent the following year. But moderate changes in cotton allotments and loan rates for either feed grains or cotton would result in a relatively small change in soybean acreage.

SOYBEANS: ACREAGE RESPONSE TO PRICE AND FARM PROGRAM CHANGES

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INTRODUCTION

Soybean acreage has steadily expanded from about 1 million acres harvested for beans in the early 1930's to over 42 million acres in 1970. Because demand for soybeans expanded more or less simultaneously with supply, soybean prices have not been unduly depressed, nor have carryovers been excessive.

However, carryover has been rather large in some recent years. On September 1, 1969, it reached 29 percent of the previous year's production. But with increased demand in 1970, carryover dropped to 20 percent of the previous year's production on September 1, 1970.

The loan rate for soybeans has been the main instrument used to affect the supply of soybeans. Allotments or marketing quotas have not been imposed on soybeans, but production controls on feed grain, cotton, and wheat have affected the supply of soybeans.

This report summarizes the Aggregate Production Analysis Team's research on soybean supply response. Most of the report deals with supply response to changes in the price received for soybeans with assumed continuation of the main provisions of the Food and Agriculture Act of 1965. Some attention is given to soybean response to changes in the feed grain, cotton, and wheat programs.

Linear programming, regression analysis, and some less sophisticated techniques were used where appropriate to give alternative estimates of supply response. Each technique has strengths and weaknesses, but together they give strong indications of the response of soybean acreage and production to changes in soybean prices and Government programs for major crops.

BACKGROUND

Except for 1959, acreage planted to soybeans has increased every year since 1949. Some of the largest increases in soybean acreage occurred when allotments were reestablished for cotton, wheat, and feed grains, or farm programs were otherwise changed to reduce the acreage of these crops. A 7-percent decrease in acreage planted to soybeans in 1959 may be attributed to the removal of allotments on feed grains. Since 1950, with no substantial change in feed grains, wheat, and cotton programs, the annual increase in soybean acreage varied from less than 1 percent to 14 percent, averaging about 5.5 percent. In 1950 and 1954, when allotments were established for corn, wheat, and cotton, soybean acreage increased 27 percent and 13 percent, respectively. When allotments were removed in 1951, soybean acreage increased only 1 percent, but when allotments on corn were removed in 1959, soybean acreage decreased 7 percent.

Soybean acreage has increased in the first major areas of cultivation and expanded to new areas. Before 1950, more than 80 percent of the soybeans harvested for beans were in the North Central Region. But with rapid expansion into new areas—mainly the Delta, Southeast, and eastern part of the Great Plains—the proportion of the harvested acreage in the North Central Region has declined to about 60 percent of the U.S. acreage (table 1). The most rapid expansion has been in the Delta, where the 1966-70 acreage was more than 13 times the 1946-50 acreage. During this period, Delta States acreage increased from 5 percent of the U.S. acreage to nearly 19 percent.

In the North Central Region, increased soybean acreage is associated with a decline in acreage of oats, hay, wheat plus wheat diverted, barley plus barley diverted, cropland used for pasture, and cropland neither harvested, pastured nor diverted (table 2). From 1949 to

Table 1.—Soybeans: Acreage harvested by regions, 5-year averages, 1946-70

Period	North Central		Delta States		Southeast		Great Plains		Other		United States	
	1,000 acres	*Percent*	*1,000 acres*	*Percent*	*1,000 acres*	*Percent*	*1,000 acres*	*Percent*	*1,000 acres*	*Percent*	*1,000 acres*	*Percent*
1946-50 . . .	9,470	84.1	561	5.0	726	6.4	337	3.0	169	1.5	11,263	100.0
1951-55 . . .	12,169	77.4	1,406	9.0	1,099	7.0	726	4.6	309	2.0	15,709	100.0
1956-60 . . .	16,143	72.2	2,949	13.2	1,811	8.1	942	4.2	506	2.3	22,351	100.0
1961-65 . . .	19,926	67.1	4,713	15.9	2,807	9.5	1,584	5.3	664	2.2	29,694	100.0
1966-70 . . .	24,449	61.2	7,544	18.9	4,923	12.3	2,210	5.5	853	2.1	39,979	100.0

Source: U.S. Department of Agriculture, Statistical Reporting Service, Crop Production, 1969 and earlier issues.

1964, the acreage either planted to or diverted from corn increased nearly as much as soybean acreage. However, corn acreage declined after control programs were adopted in 1933, and some of the land now in soybeans could have been used for corn before 1933. The trend in acreage of oats started down about the same time—1956—as chemicals became available for control of weeds in soybeans and corn. Oats were no longer needed in the rotation to control weeds.

In the Southeastern Region and Delta States, the increase in soybean acreage was associated with the decline in acreage of cotton, corn plus corn diverted, cropland pasture, cropland not pastured and not harvested, hay, and oats. Total land in farms and cropland harvested, plus diversion in the Delta States and in the Southeastern Region, declined from 1949 to 1964. During 1962-68, over 4 million acres of new cropland were brought into production in both regions. A large part of the new cropland has been used for soybean production.

Table 2.—Changes in soybean acreage and other land uses, by regions, 1949-64

Land use	Southeast	Delta States	North Central	Great Plains
	1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*
Soybeans	2,047	4,392	11,599	1,243
Oats	-636	-130	-12,220	-2,132
Wheat plus diversion .	-325	595	-1,395	-8,790
Barley plus diversion	73	2	-347	2,260
Cotton	-3,566	-3,062	-244	---
Hay	-1,126	-240	-1,841	-1,890
Corn plus diversion . .	-3,261	-2,211	9,983	-1,057
Grain sorghum plus diversion	183	100	568	6,112
Cropland used for pasture	-2,457	-1,006	-4,403	-379
Cropland not harvested, pastured, or diverted	-6,711	-619	-4,329	1,194
Total land farmed .	-36,308	-6,056	-17,628	13,814

Source: U.S. Department of Commerce, Bureau of the Census, U.S. Census of Agriculture, 1950 and 1964. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Feed Grain and Wheat Programs, Statistical Summary, 1966.

Increased soybean acreage in the four Great Plains States adjacent to the North Central Region was largely associated with a decrease in wheat plus wheat diverted, oats, hay, corn plus corn diverted, and cropland not harvested and not pastured. During this period, land used for grain sorghum and barley increased more than that used for soybeans.

Many factors—including development of the combine, increased use of tractor power, development of varieties adapted to new areas, chemical weed control, and acreage restrictions on feed grain, wheat, and cotton—have contributed to the increase in soybean acreage. The most important factor probably has been the increase in demand for protein and oil. In 20 of the last 24 years, total disposition of soybeans increased over the previous year (fig. 1). This increase has generally taken place with little or no decline in price received. A simultaneous expansion of demand for soybeans allowed increased supply, without serious loss of the profit advantage which soybeans had over many competing crops.

Income advantages, or disadvantages, that soybeans have over many competing crops with present technology, soybeans selling at $2.20 per bushel, and other crops selling at the prices received in 1970, are shown in tables 3-6. These tables show average returns above variable costs for areas or resource situations within areas (fig. 2)[1]. Yields per acre are shown in

[1] The areas and resource situations are described in detail in: Selected U.S. Crop Budgets: Yield, Inputs, and Variable Costs. Vol. I. Southeast; Vol. II. North Central; Vol. III. Great Plains; Vol. IV. Northwest; and Vol. V. South Central. April 1971.

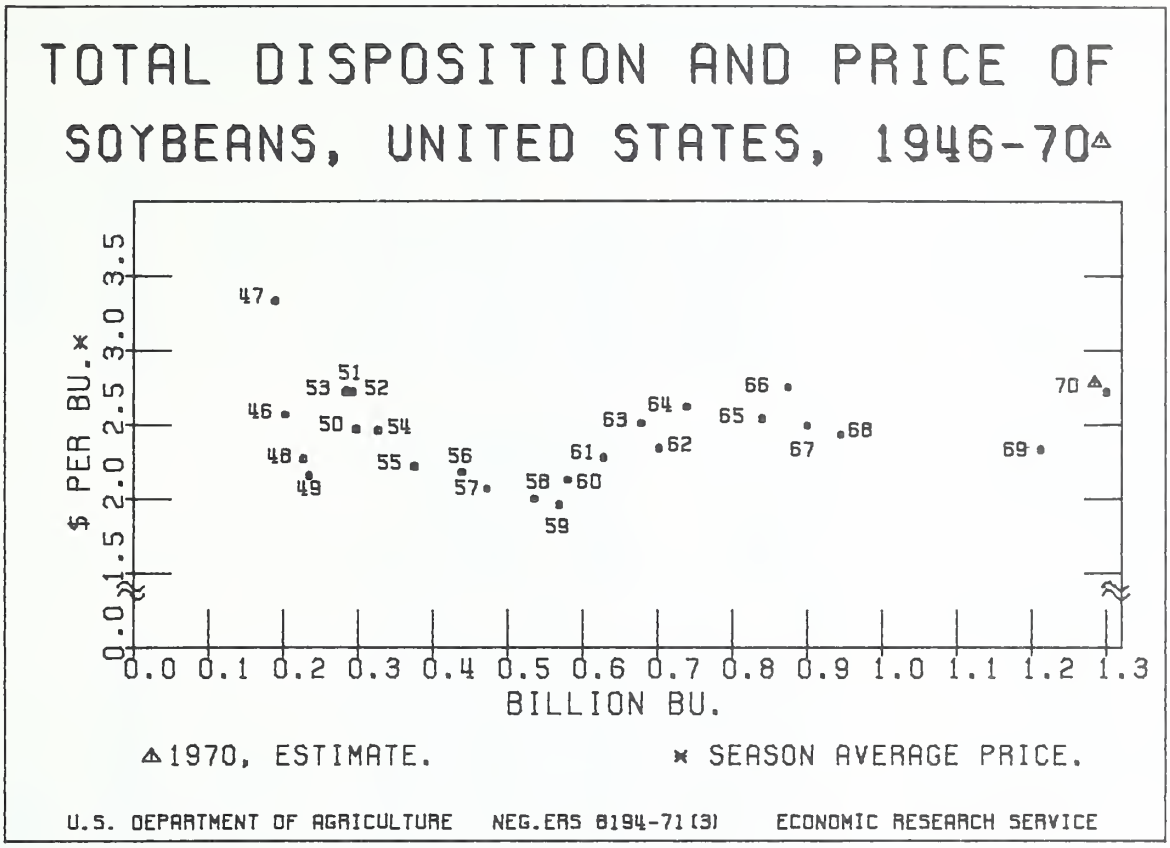

Figure 1

parentheses below the returns figures, so that adjustments can be made for other prices. Data in these tables show that at the prices used, soybeans generally have an advantage over oats, and frequently have an advantage over wheat, barley, flax, and hay. Corn has an advantage over soybeans in most of the Corn Belt, eastern South Dakota, eastern Kansas, the more productive soils in the Mississippi Delta area, the clay hills in Alabama and Mississippi, and the Piedmont and Coastal Plain areas in North Carolina. Soybeans have an advantage over cotton in the Piedmont, Coastal Plain, and Black Belt in the Southeast and less productive soils in northeastern Arkansas. But cotton has a decided advantage over soybeans in the Mississippi Delta area; Brown Loam areas of Tennessee and Mississippi; Clay Hills, Sand Mountain, and Limestone Valley, the Missouri Bootheel; and northeastern Arkansas.

If the soybean price is increased to $2.50 per bushel, the number of areas in which soybeans have an advantage over competing crops is increased. But corn at $1.05 would still have an advantage over soybeans in a large part of the North Central Region. Cotton at 22 cents a pound would also have an advantage over soybeans in the Brown Loam and Sand Mountain-Limestone Valley areas and on sandy and loam soils in the Delta and northeastern Arkansas.

If the price received for soybeans is reduced to $1.80 per bushel, the average budgets in tables 3-6 show that soybeans would still have an advantage over oats, wheat, and barley in most areas. Areas where soybeans lose advantage over these crops are mostly in the Lake States. The average budgets also show that soybeans would lose advantage over hay in several areas in the North Central Region. In several areas outside the North Central Region, soybeans would also lose advantage over corn. Even though a large part of the acreage now used for soybeans probably was formerly used for small grains, these budgets indicate that there would be a very small shift from soybeans to small grains if the price of soybeans were reduced to $1.80 per bushel. A shift from soybeans to hay in the North Central Region would tend to be limited by the demand for hay. Probably the main effect of reducing the price of soybeans would be to reduce the incentive for participation in the feed grain program.

Historical data on returns above variable costs are not available, but changes in prices received, yields, and fertilizer use give some indication of changes in

Table 3.—Soybeans and competing crops: Returns above variable costs, Southeastern Region, 1970[1]

Area and type of soil[2]	Soybeans	Cotton	Corn	Oats	Barley	Wheat	Peanuts
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
A, Southern Piedmont	28.70	10.44	15.04	5.83	6.91	8.27	
	(25.0)	(430)	(41.6)	(43.5)	(40.1)	(28.5)	
B, Southeastern Coastal Plain	27.30	28.59	24.62	2.13	5.29	9.47	131.02
	(25.0)	(489)	(56.0)	(40.8)	(37.0)	(31.8)	(1,862)
C, Southwestern Coastal Plain	27.98	20.32	23.40	6.67		13.50	129.04
	(27.0)	(459)	(51.0)	(46.1)		(33.3)	(1,824)
D, Limestone Valley	32.98	46.42	18.52	5.59		8.20	
	(30.1)	(563)	(46.1)	(46.1)		(31.0)	
E, Clay Hills:							
Soil I, level upland	33.27	47.84	26.13	10.93			
	(27.0)	(555)	(55.0)	(49.5)			
Soil II, bottom rolling upland	31.73	10.01	32.18				
	(32.0)	(491)	(68.8)				
F, Black Belt	30.17	16.36	6.29	.64			
	(27.4)	(423)	(39.2)	(38.0)			
G, Tennessee Brown Loam:							
Soil I, bottom land	37.74	72.48	38.18	11.35		16.94	
	(30.0)	(680)	(68.0)	(49.5)		(34.2)	
Soil II, upland	23.98	58.91	20.90	8.87		15.03	
	(23.0)	(590)	(50.0)	(44.1)		(31.5)	
H, North Carolina Piedmont	15.27	-6.34	19.06	-.47	2.80	21.89	
	(22.8)	(573)	(54.0)	(47.2)	(44.7)	(43.5)	
J, North Carolina Coastal Plain	14.86	-1.96	24.82	5.62	3.08	21.73	163.09
	(23.5)	(587)	(63.0)	(54.2)	(44.7)	(43.5)	(2,328)

[1] Budgets are for the large farm resource situation—more than 100 acres of cropland. Returns assume the following U.S. average prices received:

Soybeans	$2.20 per bushel	Rice	$4.90 per cwt.
Cotton	.22 per pound	Peanuts	.12 per pound
Corn	1.05 per bushel	Flax	2.83 per bushel
Oats	.63 per bushel	Hay	22.00 per ton
Barley	.90 per bushel	Grain sorghum	.90 per bushel
Wheat	1.30 per bushel		

Figures in parentheses are yields per acre. [2] Areas of the Southeastern Region are shown in fig. 2.

advantage or disadvantage of soybeans through time. In this study, returns above fertilizer cost were used as a measure of the net effects of these three factors on returns above variable costs. Production costs (except for fertilizer) for soybeans, corn, and oats seem to have followed similar trends during the period studied, because the same or similar equipment is used for all three crops. Changes in size of tractor and equipment would have about the same effect on costs for each crop.

From 1946 to about 1956, the relationship between prices received for soybeans and corn did not change greatly, but after 1956, prices received for soybeans increased relative to those for corn. This increase was partly offset by increased corn yield, which was greater than the increased soybean yield. In the North Central Region, soybean returns above fertilizer cost increased slightly, relative to corn returns above fertilizer costs (table 7). On the other hand, net returns above fertilizer costs from soybeans, relative to corn, declined in the Southeast. In some parts of the Southeast, soybeans may have lost advantage over corn in the last 2 decades. In the Great Plains and Delta Regions, the data indicate little change in the advantage or disadvantage of soybeans over corn.

Regional data on returns above fertilizer cost for the North Central and Great Plains Regions indicate that the advantage of soybeans over oats has not changed greatly since about 1950, but in the Southeast, soybeans may have gained advantage over oats.

The ratio of soybean returns to cotton returns was not included in the analysis, because these returns did not greatly affect cotton or soybean acreage during most

Table 4.—Soybeans and competing crops: Returns above variable costs, Delta States, 1970[1]

Area and type of soil[2]	Soybeans	Cotton	Corn	Oats	Barley	Wheat	Rice
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
A, Mississippi Brown Loam:							
Soil I, bottom	16.55	75.93	21.56				
	(25.0)	(800)	(70.0)				
Soil II, terrace	16.55	50.76	2.78			11.01	
	(25.0)	(675)	(50.0)			(30.0)	
Soil III, hillside	6.00	32.74	-5.62			3.00	
	(20.0)	(600)	(40.0)			(24.0)	
B, Delta:							
Clay soil	24.95	27.39		7.52		7.75	93.14
	(22.0)	(610)		(42.0)		(28.0)	(3,825)
Loam soil	29.18	60.40		15.60		12.58	93.14
	(24.0)	(710)		(54.0)		(32.0)	(3,825)
Sandy soil	26.40	81.11		15.60		12.58	
	(22.0)	(790)		(54.0)		(32.0)	
D, Northeast Arkansas:							
Clay soil	21.97	8.16	9.97	15.25		7.02	
	(21.0)	(460)	(42.0)	(55.0)		(28.0)	
Loam soil	19.83	40.61	16.17	23.80		9.48	
	(22.0)	(590)	(48.0)	(68.0)		(30.0)	
Sandy soil	24.67	50.67	24.23	12.98		5.53	
	(24.0)	(650)	(58.0)	(54.0)		(26.0)	
Terrace soil	20.35	16.39	14.00	22.04		10.55	
	(25.0)	(475)	(42.0)	(68.0)		(30.0)	
L, Southwest Louisiana	32.44	9.71	3.06			.78	
	(29.4)	(400)	(37.2)			(26.4)	

[1] See footnote 1 to table 3. [2] Areas of the Delta States are shown in fig. 2.

of the period. Before 1966, the cotton price support level generally gave cotton a clear advantage over soybeans. Marketing quota penalties were in effect on cotton, and farmers generally could not afford to plant more than the allotment, and thus stay out of the program. In many areas, farmers tended to plant the full allotment to cotton, and plant soybeans on a large part of the remaining cropland. In 1966, when the loan rate for cotton was lowered to 90 percent of the world price, cotton produced without price support payment lost advantage over soybeans in most of the Southeast. However, cotton retained advantage over soybeans in most of the Delta and Brown Loam, Clay Hills, and Sand Mountain areas of the Southeast.

RESPONSE TO PRICE

Programmed Estimates

A linear programming model was used to quantify acreage and production response to changes in prices of soybeans and competing crops. The direction of this response is fairly evident from the budgets presented in tables 3-6.

The model used in this analysis is designed to evaluate shortrun (1-year) production response to changes in prices received, cost rates, and provisions of the feed grain, cotton, and wheat programs specified for 1969 under the Food and Agriculture Act of 1965. There are 59 submodels for 47 production areas where soybeans are produced. Each submodel represents the aggregate of resources on a group of farms that are assumed to have similar resource situations and to display similar patterns of production response. Each submodel is used to estimate the aggregate production response of a resource situation to a change in a parameter—usually a parameter relating to a provision in a Government program. The total U.S. response to a given change in a parameter is estimated by summing the results from each of the submodels.

The individual linear programming matrices are conceptually quite simple. The activities consist of various methods of growing the major crops in the area—crop enterprises. The main physical restraint is cropland. The matrices also contain institutional

Table 5.—Soybeans and competing crops: Returns above variable costs, North Central Region, 1970[1]

Area[2]	Soy-beans	Corn	Oats	Barley	Sor-ghum	Winter wheat	Durum wheat	Other spring wheat	Rye	Flax	Hay
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
A	13.51	18.15	12.65	21.53			24.23	19.65	14.08	13.16	41.76
	(14.0)	(50.3)	(49.3)	(41.8)			(30.1)	(26.8)	(26.6)	(9.5)	(1.68)
B	10.55	19.51	11.70	21.56				17.10	4.36	17.63	13.61
	(12.8)	(55.0)	(43.4)	(38.3)				(23.8)	(16.2)	(9.9)	(1.85)
C	29.87	39.03	20.48	27.51				21.96	11.69	26.33	25.83
	(22.2)	(80.6)	(56.5)	(44.2)				(26.4)	(22.8)	(13.3)	(2.93)
D	47.05	51.09	22.42		40.95	13.48					24.94
	(30.9)	(91.8)	(55.4)		(81.3)	(24.7)					(2.98)
E	47.09	55.31	23.75			18.12					25.09
	(31.2)	(101.9)	(58.0)			(29.1)					(3.06)
F	36.72	45.27	22.01			14.10					23.06
	(27.0)	(92.0)	(56.0)			(26.4)					(2.72)
G	38.94	46.30	14.68								17.89
	(28.5)	(86.5)	(44.7)								(2.37)
H	36.98	48.82	10.64		38.70	16.03					25.15
	(27.5)	(78.5)	(39.1)		(71.8)	(27.3)					(2.85)
I	29.20	39.25	12.51		35.49	14.03					12.36
	(23.9)	(73.1)	(40.7)		(70.3)	(28.2)					(1.74)
J	26.32	33.34	10.27		23.28	18.30					9.56
	(22.6)	(65.6)	(37.8)		(60.2)	(29.7)					(1.66)
K[3]	28.70	46.28				23.27					9.40
	(22.7)	(78.9)				(33.3)					(1.84)
M	15.29	48.26	23.47			17.80					25.77
	(20.1)	(82.8)	(56.4)			(28.4)					(2.47)
N	22.12	49.70	20.71			29.18					26.33
	(20.1)	(84.8)	(59.6)			(37.3)					(2.53)
O	43.21	60.36	27.87			21.43					36.49
	(30.0)	(104.0)	(65.6)			(40.8)					(3.20)
P	43.10	60.25	22.71			23.65					27.93
	(30.1)	(102.1)	(57.0)			(37.2)					(2.60)
Q	49.10	64.80	22.57			25.95					23.75
	(32.3)	(107.1)	(58.6)			(43.5)					(2.50)
R	29.54	41.26	15.43			30.88					20.73
	(23.1)	(85.1)	(45.6)			(42.2)					(2.20)
S	27.43	26.86	7.64			12.04					8.65
	(23.1)	(65.5)	(40.3)			(34.5)					(1.60)
T	22.92	36.05	17.46			24.07					27.95
	(20.4)	(72.8)	(59.9)			(41.2)					(2.55)
U	24.82	30.85	18.29			19.22					26.46
	(21.6)	(67.3)	(56.2)			(36.8)					(2.52)
V	34.11	53.35	14.75			18.91					23.03
	(26.2)	(95.0)	(51.5)			(39.9)					(2.30)
W	30.77	48.78	10.27			17.17					18.14
	(25.2)	(90.4)	(45.0)			(36.9)					(2.10)
X	34.19	49.21	20.55			20.78					25.86
	(24.8	(88.6)	(62.1)			(39.3)					(2.04)
Y	32.56	50.85	16.02			22.37					23.91
	(24.3)	(86.6)	(52.3)			(35.8)					(1.99)
Z	29.91	41.89	11.22			19.04					15.69
	(23.5)	(77.6)	(40.9)			(33.7)					(1.62)

[1] See footnote 1 to table 3. [2] Areas of the North Central Region are shown in fig. 2. [3] Cotton: net returns, $51.69; yield, 557 pounds of lint.

Table 6.—Soybeans and competing crops: Returns above variable costs, Great Plains Region, 1970[1]

Area[2]	Soy-beans	Corn	Oats	Barley	Sor-ghum	Winter wheat	Durum wheat	Other spring wheat	Flax	Hay
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
C	21.13		10.46	13.04			18.70	19.56	10.68	10.92
	(16.5)		(48.9)	(34.7)			(26.2)	(24.6)	(8.4)	(1.75)
D	17.91	10.50	6.86	10.48	10.08	4.39		8.76	13.60	10.60
	(14.5)	(25.2)	(33.0)	(26.9)	(25.0)	(14.1)		(14.7)	(7.8)	(1.25)
F	24.86	26.73	10.68	13.30	19.03			11.24	17.03	17.22
	(17.9)	(47.8)	(41.5)	(29.6)	(39.6)			(17.1)	(9.6)	(1.85)
L	39.47	38.43	11.65		31.09	16.36				19.91
	(25.4)	(63.2)	(37.0)		(63.0)	(25.0)				(2.32)
V	20.24	12.34	3.63	5.46	15.22	13.09				18.74
	(15.8)	(34.5)	(19.3)	(18.7)	(36.0)	(22.6)				(2.23)
W	25.93	29.28	6.55	4.64	29.08	12.87				18.60
	(19.8)	(59.5)	(28.2)	(20.2)	(58.2)	(24.6)				(2.33)

[1] See footnote 1 to table 3. [2] Areas of the Great Plains Region are shown in fig. 2.

Table 7.—Soybeans: Ratio of returns to returns from corn and oats, 5-year averages, 1945-69[1]

Crop and period	North Central	Great Plains	South-east	Delta
Soybeans to corn:				
1945-49	0.77	0.82	1.49	1.57
1950-54	.81	.87	1.38	1.46
1955-59	.76	.85	1.15	1.57
1960-64	.90	.95	1.17	1.56
1965-69	.88	.83	.96	1.53
Soybeans to oats:				
1945-49	1.84	1.78	1.54	1.74
1950-54	2.17	3.13	1.58	1.47
1955-59	1.95	2.16	1.88	2.01
1960-64	2.09	2.45	2.21	1.78
1965-69	2.01	2.37	1.99	1.70

[1] Gross returns less cost of fertilizer.

restraints in the form of wheat allotments, domestic and total cotton allotment, feed grain base, etc., for the whole area. Linear programming models are generally normative, but the models used in this analysis were made more predictive through the use of flexibility restraints. These restraints appear in the linear programming matrices in the form of upper and lower bounds on an individual crop enterprise or on a group of enterprises. Flexibility restraints were used to reflect the probable limits on farmers' aggregate response from one year to the next. Various techniques were used to estimate flexibility restraints—from subjective judgment to multiple regression. The method depends upon the reliability and availability of data and nature of the alternative considered. The flexibility restraints were reestimated for each major change in any of the model's parameters.

The model was used to make four estimates of soybean acreage with the price received per bushel for soybeans at $2.50, $2.25, $2, and $1.80. Prices assumed for other major crops were: Corn, $1.05 per bushel; wheat, $1.30 per bushel; and cotton, 22 cents per pound. Program provisions were assumed to be the same as in 1969, including 30 cents per bushel for corn and $1.52 per bushel for wheat. Net returns and yields per acre used in this analysis were generally the same as those shown in tables 3-6. The model apparently underestimated the acreage of soybeans at all price levels. However, the change in production, as the assumed price received for soybeans is reduced from $2.50 per bushel, seems reasonable, and is in line with estimates obtained from regression analysis.

As the price received for soybeans is reduced from $2.50 to $2.20 per bushel, the model estimates a reduction of 600,000 acres, or 1.4 percent (table 8). A

Table 8.—Soybeans: Response of programmed estimates of planted acreage to change in expected price

Change in expected U.S. price received per bushel[1]	Reduction in planted acreage of soybeans	
	Million acres	*Percent*
$2.50 to $2.20	0.6	1.4
$2.20 to $2.00	1.7	4.1
$2.00 to $1.80	1.4	3.5

[1] Farmers' price expectations.

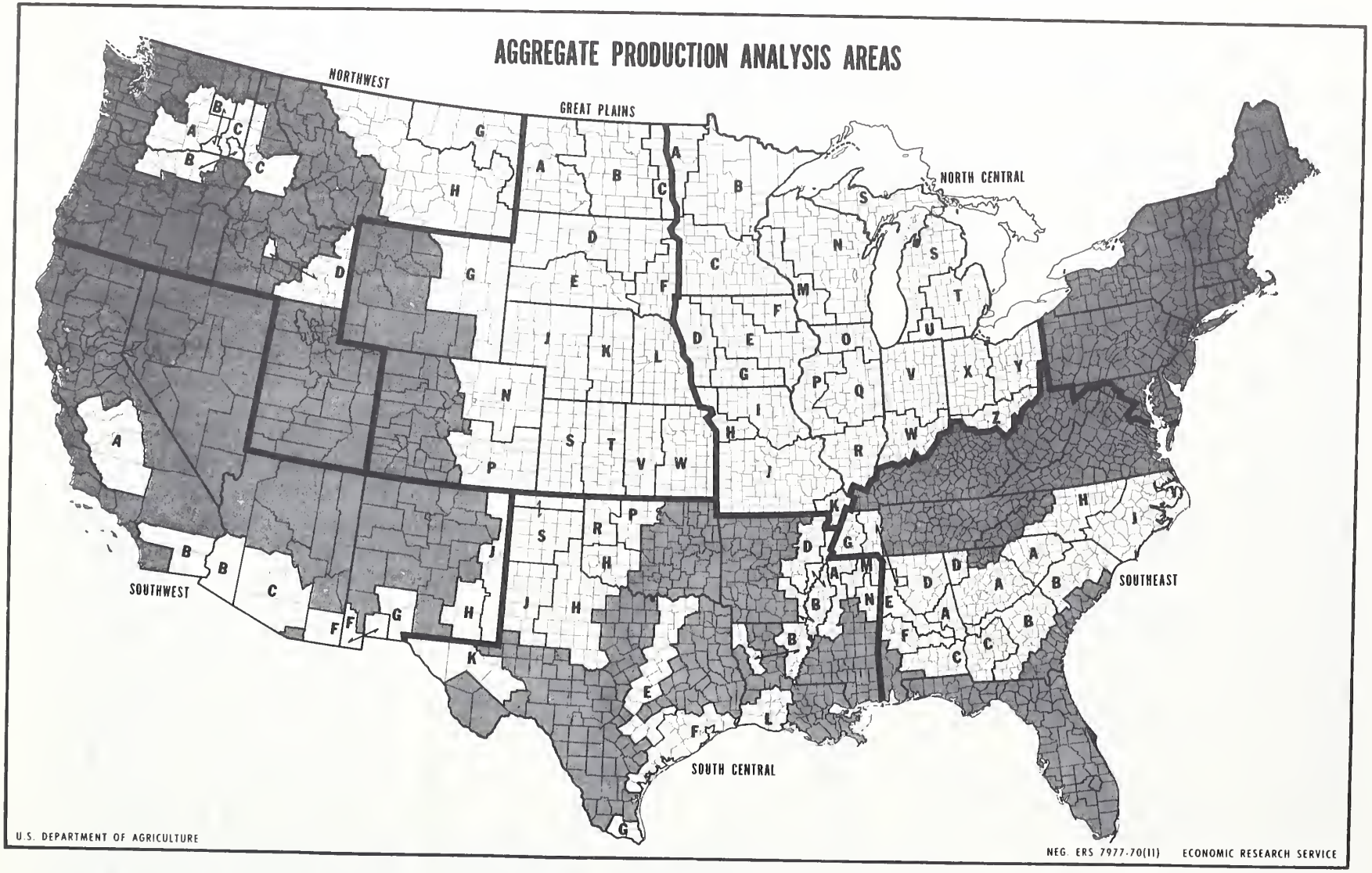
AGGREGATE PRODUCTION ANALYSIS AREAS
NORTHWEST
GREAT PLAINS
NORTH CENTRAL
SOUTHWEST
SOUTHEAST
SOUTH CENTRAL
U.S. DEPARTMENT OF AGRICULTURE
NEG. ERS 7977-70(11) ECONOMIC RESEARCH SERVICE

Figure 2

further reduction in price received for soybeans from $2.20 per bushel to $2 per bushel would reduce planted acreage by another 1.7 million acres, or 4.1 percent of the acreage at $2.20 per bushel. A still further reduction in price received for soybeans from $2 per bushel to $1.80 per bushel would reduce acreage by 1.4 million acres, or 3.5 percent of the acreage at $2 per bushel. In applying these estimates to a particular year, they must be adjusted for the upward trend in soybean acreage. After 1950, when there was no major change in programs for competing crops and the price received for soybeans in the previous year was more than $2.20 per bushel, the increase in acreage of soybeans over the previous year averaged about 5 percent.

The model estimated that about half the land removed from soybeans—as the price received is reduced from $2.50 to $1.80 per bushel—would be planted to corn. The remainder was distributed among other grain crops. A reduction in the price of soybeans would have increased the pressure on farmers to stay out of the 1965-70 feed grain programs.

For some farmers, the increased income from additional corn would more than offset the loss of support payments on corn and reduced income from soybeans. Although, historically, most of the increase in soybean acreage was associated with decreased acreage of oats and other crops with relatively low net returns, a reduction in the price of soybeans to $1.80 per bushel is generally insufficient to induce a substantial shift to other crops such as oats, hay, and cropland pasture.

Regression Analysis

Regression analysis was used to give an alternative estimate of supply response to changes in price. In this part of the analysis, soybean acreage harvested was correlated with prices received, gross returns less fertilizer cost, soybean loan rate, allotments or diversion programs in effect on feed grain, and either time or soybean acreage harvested the previous year. The latter variable was used to reflect the effect of various factors in previous years. The specific variables were:

A = Soybean acreage harvested, current year.

X_1 = Soybean acreage harvested, previous year.

X_2 = Allotments or diversion programs in effect for feed grains (allotments were frequently in effect for cotton and wheat at the same time).

X_3 = Net returns above fertilizer cost for soybeans in previous year.

X_4 = Ratio of gross returns less fertilizer cost for soybeans to gross returns less fertilizer cost for corn (previous year).

X_5 = Ratio of gross returns less fertilizer cost for oats to gross returns less fertilizer for soybeans (previous year).

X_6 = U.S. loan rate for soybeans.

X_7 = Time.

X_8 = Price received for soybeans in the previous year.

X_9 = Ratio of price received for soybeans to price received for corn (previous year).

X_{10} = Ratio of price received for oats to price received for corn.

Four equations were developed for each of four regions. The general forms of these equations were:

(1) $A = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6$

(2) $A = a + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7$

(3) $A = a + b_1X_1 + b_2X_2 + b_6X_6 + b_8X_8 + b_9X_9 + b_{10}X_{10}$

(4) $A = a + b_2X_2 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10}$

In the first equation, the independent variables included acreage harvested the previous year, allotments in effect on feed grains, U.S. loan rate for soybeans, soybean gross returns less fertilizer cost, ratio of soybean net returns to corn net returns, and ratio of oats net returns to soybean net returns. In the second equation, time was substituted for soybean acreage harvested the previous year. In the third equation, price variables were substituted for gross returns less fertilizer cost variables. For the last equation, both time and price variables were substituted.

The coefficient of determination was reduced in each region when time was substituted for acreage harvested the previous year as an independent variable. Except for the North Central Region, the coefficient of determination was also reduced when the price variables were substituted for the gross return less fertilizer cost variables. In the North Central Region, the third equation, using acreage harvested the previous year and the prices received variables, gave only a slightly higher coefficient of determination than equation (1), using acreage harvested the previous year and the gross return less fertilizer cost variables.

Equations shown in table 9 were taken from the first equation for each region. Variables not significant at the 10-percent level were dropped (table 9). The acreage harvested the previous year and allotments in effect on feed grains were included in the equations for all four regions. In the North Central Region, the other independent variables included the ratio of soybean returns above fertilizer costs to corn returns and the

Table 9.—Soybean acreage harvested: Regression analysis

[Equation $A = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$]

Region	Intercept	b values					R^2	Standard deviation	Standard error of estimate	F	$1-\frac{S}{\sigma}$
		X_1	X_2	X_3	X_4	X_5					
North Central	1,077.1	0.9124 (23.20)	1,298.250 (2.79)	30.477 (1.28)	-46.995 (1.49)		0.980	5,397.9	720.4	318.1	86.7
Great Plains	-914.7	.9006 (17.5)	170.346 (2.4)	11.288 (3.9)			.966	669.6	134.1	176.4	80.0
Delta	1,053.8	.9074 (15.92)	623.108 (3.29)			27.123 (2.34)	.990	2,450.1	251.9	718.6	90.7
Southeast	-923.3	.9121 (19.4)	273.132 (2.4)			26.190 (3.4)	.986	1,578.5	194.4	520.5	87.7

A = 1,000 acres of soybeans harvested in current year. X_1 = 1,000 acres of soybeans harvested in previous year. X_2 = allotment in effect on feed grain, a 0 or 1 variable. Allotments were in effect at the same time on cotton and wheat, and were also in effect in 1969 and 1960. X_3 = ratio of net return above fertilizer cost from soybeans to net returns above fertilizer cost from corn in previous year. X_4 = ratio of returns above fertilizer cost from oats to returns above fertilizer costs from soybeans in previous year. X_5 = returns above fertilizer cost from soybeans in previous year. Numbers in parentheses are T values of the coefficient.

ratio of returns above fertilizer costs from oats to soybean returns. In The Delta and Southeastern Regions, the only other variable included was soybean returns above fertilizer costs. In the Great Plains, the only other variable included was the ratio of soybean net returns above fertilizer costs to the corresponding corn returns.

The U.S. loan rate for soybeans was not significant at the 10-percent level when included as an independent variable in these equations.[2] However, it was significant at the 10-percent level in a few equations when time was included as an independent variable. The apparent lack of influence of the loan rate on soybean acreage may be because the price received for soybeans was above the loan rate during much of this period. In 17 of the 24 years included in the analysis, the price received exceeded the loan rate by more than 5 cents per bushel. If the price should be closer to the loan rate in the future, the loan rate could have more influence on soybean acreage than the historical analysis would indicate.

The coefficient of determination for the equations with harvested acreage of soybeans as the dependent variable varied from 0.966 in the Great Plains to 0.99 in the Delta. The standard error of estimate varied from 134,100 acres in the Great Plains to 720,400 acres in the North Central Region. When expressed as a percentage of the acreage in 1969, the standard error of estimates varied from 2.9 percent in the North Central Region to 6.4 percent in the Great Plains Region.

Because of the generally high intercorrelation between independent variables, it is difficult to estimate the change in soybean acreage that is associated with a change in a particular independent variable. However, it would appear that a very large proportion of the increase in soybean acreage is associated with the trend variable (acreage in the previous year). When time or acreage the previous year is used as the only independent variable, the coefficients of determination vary from 0.889 to 0.986. The addition of more independent variables to the equation results in only slightly higher coefficients. But the reduction in the standard error of estimate is much more than proportional to the increase in coefficients of determination. The standard error of estimate of the equations in table 9 is 16 to 64 percent lower than when either time or acreage the previous year is used as the only independent variable. These equations show that allotments on major competing crops and variables showing net returns in the previous year have some influence on annual fluctuation in soybean acreage. The growth in soybean acreage, however, is a long-time adjustment to the almost continuous advantage which soybeans have had over many competing crops. The soybean acreage expansion without an accompanying serious price decline was made possible by the simultaneous expansion in soybean demand. The simultaneous expansion of production and demand prevented the appearance of the cobweb effect for the past 20 years or more: That is, increased production in a given year has not depressed prices enough in that year to cause decreased production in the following year.

The effects of changing the price of soybeans on harvested acreage as derived from the equations, with harvested acreage as the independent variable, are shown in table 10. These estimates were obtained by estimating net returns above fertilizer costs for soybeans at each price with projected yields and fertilizer costs for 1970. Similar estimates were made for corn and oats, using

[2] This differs from the result obtained by Houck and Subotnik. See: Houck, James P. and Subotnik, Abraham, "The U.S. Supply of Soybeans: Regional Acreage Function." Agr. Econ. Res. 21:99-108, Oct. 1969.

Table 10.—Soybean harvested acreage: Estimated first differences at selected soybean prices

Price received per bushel for soybeans in previous year	Change in harvested acreage from the previous year, estimated from equations with—	
	Acreage as the dependent variable	Change in acreage as the dependent variable
	Million acres	*Million acres*
$2.50	1.2	1.9
$2.20	.2	1.0
$2.00	-.8	.2
$1.80	-1.9	-.7

U.S. prices of $1.05 and 63 cents per bushel, respectively. The resulting net return variables were inserted in the equations in table 9. With soybeans selling at $2.50 per bushel, the area planted the following year will increase approximately 1.2 million acres. The soybean harvested area is reduced approximately 1 million acres as the previous year's soybean price is successively reduced from $2.50 a bushel to $2.20, to $2, and to $1.80 per bushel (table 11).

These equations show an increase of nearly 2.4 million acres when allotments are established on the major competing crops. But high intercorrelation between independent variables may reduce the accuracy of the estimate more than is indicated by the T value of the b coefficients.

When the change in soybean acreage from the previous year was used as the dependent variable, the independent variables which were statistically significant at the 10-percent level differed somewhat from those which were significant in the equations with soybean acreage harvested as the dependent variable. The years affected by the change in allotments on other crops were omitted from this part of the analysis. In the North Central Region, the only independent variable was the ratio of returns above fertilizer costs from oats to the previous year's corresponding returns from soybeans.

In the Delta, the independent variable was the ratio of oats prices to soybean prices. In the Southeast, gross returns less fertilizer costs from soybeans and from oats were treated as independent variables. The coefficient of determination varied from 0.28 in the North Central Region to 0.44 in the Great Plains (table 12). The coefficient of determination for the equation using absolute acreage change as the *dependent* variable was substantially below the coefficient for equations using soybean acreage harvested for the dependent variable. The standard error of estimate was about the same, however, for the two equations in each region. With soybeans selling at $2.50 per bushel, equations using the acreage change from the previous year as the dependent variable gave an increase of 1.9 million acres, instead of the 1.2 million acres derived from equations with soybean acreage harvested as the dependent variable (table 10). But the reduction in soybean acreage as the price is reduced from $2.50 per bushel is about the same for each set of equations (table 11).

Table 11.—Soybean acreage: Regression estimates of response to change from price received per bushel in previous years

Price change from previous year per bushel	Reduction in acreage harvested estimated from equations with—			
	Acreage as the dependent variable		Change in acreage as the dependent variable	
	Mil. acres	*Pct.*	*Mil. acres*	*Pct.*
$2.50 to $2.20	1.0	2.4	0.9	2.1
$2.20 to $2.00	1.0	2.4	.8	2.0
$2.00 to $1.80	1.1	2.7	.9	2.1

Feed Grain Program Changes and Soybean Acreage

The main changes in the feed grain program considered in this report were lowering the support payment rate, the loan rate, and the price received for corn by 5 cents per bushel, with equivalent changes for grain sorghum and barley. The linear programming model showed an increase of only about 100,000 acres in the soybean acreage as a result of the changes in the feed grain program. Most of the increase in soybean acreage would be in one State in the North Central Region. However, an increase in the shadow price[3] for soybeans in each area of the North Central Region suggests that the soybean acreage in these other areas may increase also, even though it does not show up in the model estimates.

The regression equations show an increase of about 470,000 acres of soybeans as corn price is reduced 5 cents per bushel, which is much larger than the increase obtained with the linear programming model. This estimate of the soybean acreage increase seems more in line with the estimated increase when the price of soybeans is raised 5 cents per bushel, as obtained by both the regression and the linear programming models.

[3] The shadow price is increased in receipts if the effective constraint on soybean acreage is increased by one unit.

Table 12.—Soybean acreage: Regression analysis of first differences

[Equation $\triangle A = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$]

Region	Intercept	b values					R^2	Standard deviation	Standard error of estimate	F	$1 - \frac{S}{\sigma}$
		X_1	X_5	X_{10}	X_3	X_{11}					
North Central	4,612.6	-78.87 (2.6)					0.28	677.7	590.2	6.7	13
Great Plains	-884.0		11.23 (4.0)				.44	167.8	129.1	16.2	23
Delta	1,605.1			-37.62 (3.2)			.32	324.6	272.7	10.6	16
Southeast	208.5				21.34 (3.5)	-21.48 (1.5)	.36	245.1	205.6	6.0	16

$\triangle A$ = change in soybean acreage harvested from previous year (1,000 acres). X_{10} = ratio of price received for oats to price received for soybeans in previous year. X_{11} = return above fertilizer cost from oats in previous year. For other symbols see table 9.

COTTON PRICE AND SOYBEAN ACREAGE

Both the linear programming model and estimates made from other data indicate a very small increase in soybean acreage if the price received for cotton drops from 22 to 20 cents per pound. An increase of only about 78,000 acres is estimated by the linear programming model. However, due to the limited number of resource situations used in the model, this estimate may be too low. An alternative estimate, using the acreage of cotton planted on nondomestic allotment in 1969, the frequency distribution of variable costs of cotton from the 1966 cotton cost survey,[4] and the budgets of returns above variable costs for soybeans and corn, is shown in table 13.

The 1969 acreage of nondomestic allotment was multiplied by an estimate of the change in proportion of cotton acreage planted if the price received is reduced from 22 to 20 cents per pound. This estimate was derived from the percentage of nondomestic allotment planted in 1969 and the distribution of variable costs taken from the 1966 cotton cost survey. The resulting estimate of land available for other uses was then allocated between soybeans and other crops, using the budgets in tables 3-6. With this method, the increase in soybean acreage as the price received for cotton drops from 22 to 20 cents per pound is estimated at about 180,000 acres (table 13). In the Southeast, the increase in soybean acreage would be relatively small. With a market price of 22 cents per pound, very little of the nondomestic allotment has been planted to cotton. Even with a drop to 20 cents per pound, a large proportion of the domestic cotton allotment would be planted to cotton, because the market price plus the support payment makes cotton the most profitable alternative. In the Delta States, cotton at 20 cents per pound generally has an advantage over soybeans at $2.20 per bushel, but the shift from cotton to soybeans would be greater than in the Southeast. Most of the shift from cotton to soybeans in the Delta States would be on clay and terrace soils.

COTTON PROGRAM CHANGES AND SOYBEAN ACREAGE

A 175,000-acre increase in soybeans would result from a decrease of 1 million acres in the domestic cotton allotment. This estimate is based on the percentage of nondomestic cotton planted in 1969, cotton costs distribution, and the budgets summarized in tables 3 and 4. Should the domestic cotton allotment be reduced by 1 million acres, about 378,000 acres of the reduction would be on farms planting cotton in areas where soybeans are produced (table 14). The proportion of this acreage that would still be planted to cotton was estimated by multiplying the domestic cotton allotment affected in each area by the percentage of nondomestic cotton allotments that was planted to cotton in 1969. The remaining 235,000 acres not planted to cotton were allocated between soybeans and other crops—mostly corn—using the budgets shown in tables 3-6. This estimate shows that 175,000 acres, or approximately three-quarters of the land not planted to cotton, would be planted to soybeans.

Most of the land that would still be planted to cotton is in the Delta. In the Southeast, soybeans still have an advantage over corn in most areas, even though this advantage has been declining in recent years.

[4] Starbird, I.R., and B.L. French. 1966 Supplement to Costs of Producing Upland Cotton in the United States, 1964. U.S. Dept. Agr., Agr. Econ. Rpt. No. 99, Sept. 1969.

Table 13.—Soybean acreage: Estimated increase as cotton price is reduced from 22 to 20 cents per pound

Area[1]	Non-domestic allotment on farms planting cotton in 1969	Reduction in proportion planted to cotton as price is reduced[2]	Land available for uses other than cotton	Estimated soybean acreage[3]
	1,000 acres	*Percent*	*1,000 acres*	*1,000 acres*
Southeast:				
B	240	8	19	11
C	111	7	8	5
D	156	14	22	14
E	68	16	11	6
F	42	14	9	7
G	139	15	21	13
J	75	8	6	2
Delta:				
A	100	15	15	12
B	625	13	81	77
D	165	12	20	18
L	22	10	2	2
M	45	10	4	3
N	35	10	4	3
North Central:				
K	124	12	15	4
Non-model	---	---	8	3
Total	---	---	245	180

[1] Southeastern and Delta areas are shown in fig. 2. [2] Taken from 1966 cotton cost survey and percent of nondomestic allotment planted in 1969. [3] Division between soybeans and other crops was a judgment estimate based on budgets shown in tables 3-6.

Table 14.—Soybean acreage: Estimated increase as cotton domestic allotment is reduced by 1 million acres

Region and area[1]	Acreage affected by reduction in domestic allotment	Proportion of non-domestic allotment not planted to cotton in 1969	Acreage available for other crops	Acreage allocated to soybeans
	1,000 acres	*Percent*	*1,000 acres*	*1,000 acres*
Northeast:				
A	13	100	13	13
B	43	92	40	30
C	20	93	19	14
D	28	81	23	17
E	12	74	9	4
F	7	83	6	6
G	13	45	11	6
H	4	100	4	2
J	13	93	12	4
Delta:				
A	18	52	9	8
B	111	32	36	34
D	29	40	12	11
L	4	86	3	3
M	8	71	6	2
N	6	87	5	4
North Central:				
K	22	24	5	3
Non-model Areas	27	82	22	14
Total	378	---	235	175

[1] Regions and areas are shown in fig. 2.

LIMITATIONS

Limitations on predictive models using regression or programming have been presented elsewhere,[5] but some limitations were especially evident in this study. These limitations are summarized below.

Linear Programming

1. Linear programming models are expensive and time-consuming to develop. After the model is developed, the time required to make specific estimates may be greater than the time available to do the work.

2. The number of submodels was limited by time and the resources available. As a result, the variety of situations existing on farms was not adequately covered.

3. Where technology has changed so that past experience is not relevant, linear programming models

[5] Schaller, W. Neill and Gerald W. Dean. Predicting Regional Crop Production. U.S. Dept. Agr. Tech. Bul. 1329, Apr. 1965.
Nerlove, Marc and Kenneth L. Bachman. The Analysis of Changes in Agricultural Supply: Problems and Approaches. Jour. Farm Econ., Vol. 42, No. 3, Aug. 1960.

are generally considered more appropriate than regression. However, in such situations, there may be very little experience to use as a base for setting flexibility bounds. In this study, there were very few years in which the acreage of soybeans declined from the previous year. As a result, there was little basis for setting lower bounds on soybean acreage, especially at the lower price levels.

4. Some restraints, such as labor and capital, were omitted because of lack of adequate data.

5. Historical fluctuation in acreages of crops excluded from the model or idle land makes it difficult to establish the total land restraint. Frequently the average absolute change in the total acreage of crops included in the model for the region is as great as average absolute change in soybean acreage. The model assumes that an increase in one crop will result in a reduction of one or more other crops, but this assumption may not be appropriate.

Regression Models

1. When prices, technology, or Government programs considered are outside the range of experience, regression models are not well-suited for projecting response. Some of the program variables and soybean prices analyzed in this report were outside the range of experience.

2. Some factors, such as risk and uncertainty, which probably affect the acreage of soybeans, are extremely difficult to quantify and were excluded from the analysis.

CONCLUSIONS

During the years since 1949, when there has been no change in programs for competing crops, the soybean acreage increased an average of 5 percent over the previous year. In 1950 and 1954, when allotments were established for feed grains, wheat, and cotton, soybean acreage increased 27 percent and 13 percent, respectively. When allotments were removed in 1951, soybean acreage increased 1 percent, but when allotments on corn were removed in 1959, soybean acreage decreased 7 percent.

In all regions, the increase in soybean acreage was associated with a decrease in acreage of oats, wheat, hay, cropland pasture, and cropland not pastured, harvested, nor diverted. The increase in soybean acreage was also associated with a decrease in cotton acreage in regions producing cotton, and for corn in all regions except the North Central.

The growth in soybean acreage is a long-time adjustment to the almost continuous advantage which soybeans have had over many competing crops in most areas and the expansion in demand for soybeans. The simultaneous expansion of soybean supply and demand has largely prevented the cobweb effect from appearing.

Because of intercorrelation between explanatory variables, it is difficult to measure how much of the change in soybean acreage is associated with each one. But it appears that most of the change in soybean acreage is associated with the trend variables (time or the previous year's acreage which reflect the continuous advantage of soybeans over many competing crops and the increased demand for soybeans. The establishment of allotments or other controls on feed grains, wheat, and cotton was also associated with the increase in soybean acreage. Coefficients of determination for regression equations relating the annual change in soybean acreage (in years with no major change in programs) with changes in price or net return variables were significant at the 10-percent level. But the size of the coefficients, ranging from 0.28 to 0.44, indicates that a large part of the annual change in soybean acreage is associated with factors other than price or net returns in the previous year.

The loan rate for soybeans as an independent variable was generally not statistically significant in this analysis. However, the price received for soybeans exceeded the loan rate by more than 5 cents per bushel in 17 of 24 years included in this analysis. If the loan rate becomes more effective in the future, it could have a greater effect on soybean acreage.

Regression analysis, using either absolute acreage or change in acreage from the previous year as the dependent variable, indicates that the upward trend in soybean acreage will continue with the price of soybeans in the previous year at $2.50 or $2.20 per bushel, with the price received for corn at $1.05 per bushel or less, and equivalent prices for other feed grains (table 15). Equations using the change in acreage from the previous

Table 15.—Soybean acreage: Relation between first-year increase and the price received the previous year

Price per bushel received for soybeans in previous year	Dependent variable	
	Absolute acreage	Change in acreage
	Mil. acres	*Mil. acres*
$2.50	1.2	1.9
$2.20	.2	1.0
$2.00	-.8	.2
$1.80	-1.9	-.7

year as the dependent variable indicate an increase in soybean acreage over the previous year, if the price of soybeans is $2 per bushel.

Differences in soybean acreage estimated by programming and regression analysis as the expected price received is reduced from $2.50 per bushel are shown in table 16.

Estimates of the increase in soybean acreage, if the price received for corn, the loan rate, and the support payment are each reduced by 5 cents per bushel, vary from 100,000 acres to 470,000 acres.

Estimates of the soybean acreage increase, if the support price of cotton drops from 22 to 20 cents per pound, vary from 80,000 acres to 180,000 acres.

If the domestic allotment for cotton is reduced by 1 million acres, the increase in acreage of soybeans is estimated at approximately 175,000 acres.

Table 16.—Soybean acreage: Reduction as expected price received is lowered

Change in expected price received per bushel[1]	Programming[2]	Regression analysis with—	
		Acreage as the dependent variable[3]	Change in acreage as the dependent variable[3]
	Mil. acres	*Mil. acres*	*Mil. acres*
$2.50 to $2.20 ..	0.6	1.0	0.9
$2.20 to $2.00 ..	1.7	1.0	.8
$2.00 to $1.80 ..	1.4	1.1	.9

[1] In the regression analysis, the previous year's price was assumed to be the expected price. [2] Planted acreage. [3] Harvested acreage.

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